Name: SID:

Discussion Section:

Exam #2
Biophysical Chemistry
Chemistry 130A
Fall 1999

Show all your work

State your assumptions and check that they hold

Information Page

R= 8.3145 J/(K mol) = 0.08206 L atm / (K mol)

F=Faraday's constant= 9.6485×10^4 C/mol

Oxidant/Reductant	Electrode Reaction	Reduction Potentials	
		ε°(V)	$\varepsilon^{\circ\prime}$(V)
$NAD^+/NADH$	$NAD^+ + H^+ + 2e^- \rightarrow NADH$	-0.105	-0.320
$H^+/H_2/Pt$	$2\ H^+ + 2\ e^- \rightarrow H_2(g)$	0.0	-0.421
Ag^+/Ag	$Ag^+ + e^- \rightarrow Ag(s)$	0.799	
Fe^{2+}/Fe	$Fe^{2+} + 2\ e^- \rightarrow Fe(s)$	-0.4402	

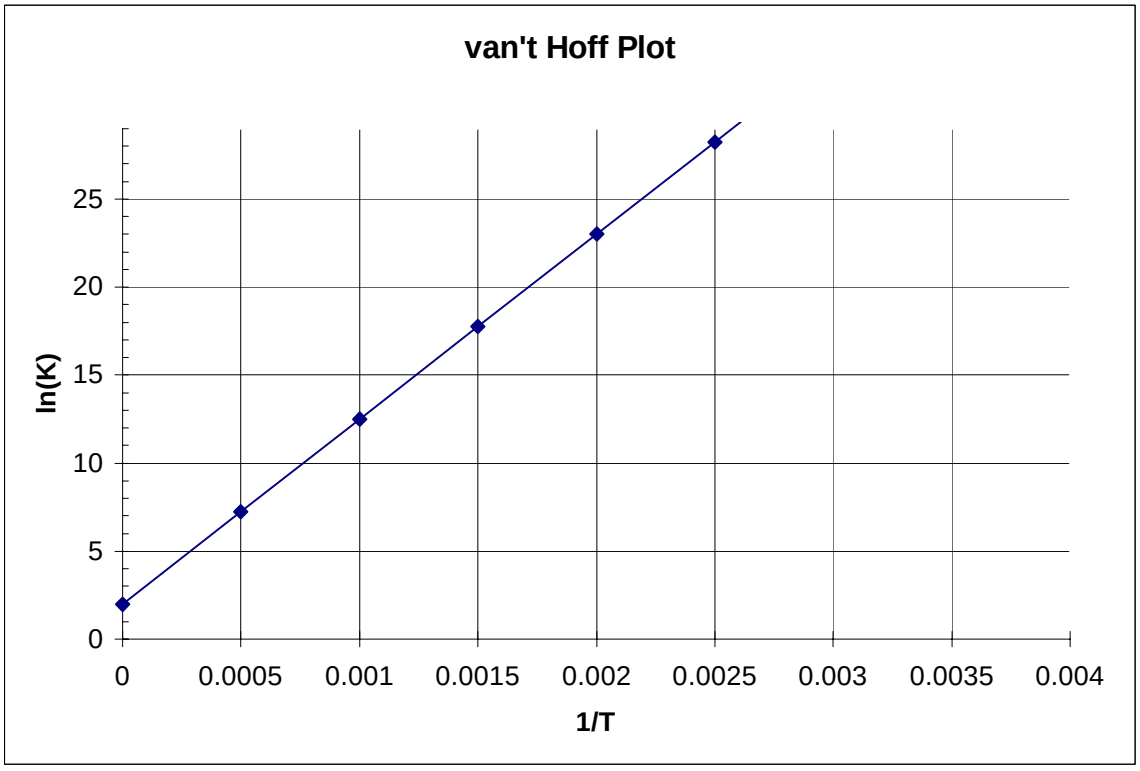
Reaction	$\Delta G^{\circ\prime}$ kJ/mol
D-Glucose -6-Phosphate $\rightarrow$ D-Fructose-6-Phosphate	1.7
Pyruvate + NADH + $H^+ \rightarrow$ Lactate + NAD^+	-25.1
ATP + $H_2O \rightarrow$ ADP + Phosphate	-31.0
2-Phosphoenolpyruvate + ADP $\rightarrow$ Pyruvate + ATP	-31.4

1. (20 pts) Consider a protein folding equilibrium,

$$\text{unfolded} \leftrightarrow \text{native}$$

(a) (5 pts) Experimentally, we know that heating a protein denatures it, i.e. as the temperature increases, [unfolded] increases. Assuming $\Delta H°$ and $\Delta S°$ are independent of temperature over the range considered, what does this imply about the sign of $\Delta H°$ for the folding reaction?

Suppose that after we ran the temperature-dependence experiments, we found



(b) (10 pts) What are $\Delta H°$ and $\Delta S°$ for this equilibrium? (Again assume that they're constant over the temperature range considered.)

(c) (5 pts) What is the chemical potential at 37 ºC for this system at equilibrium?

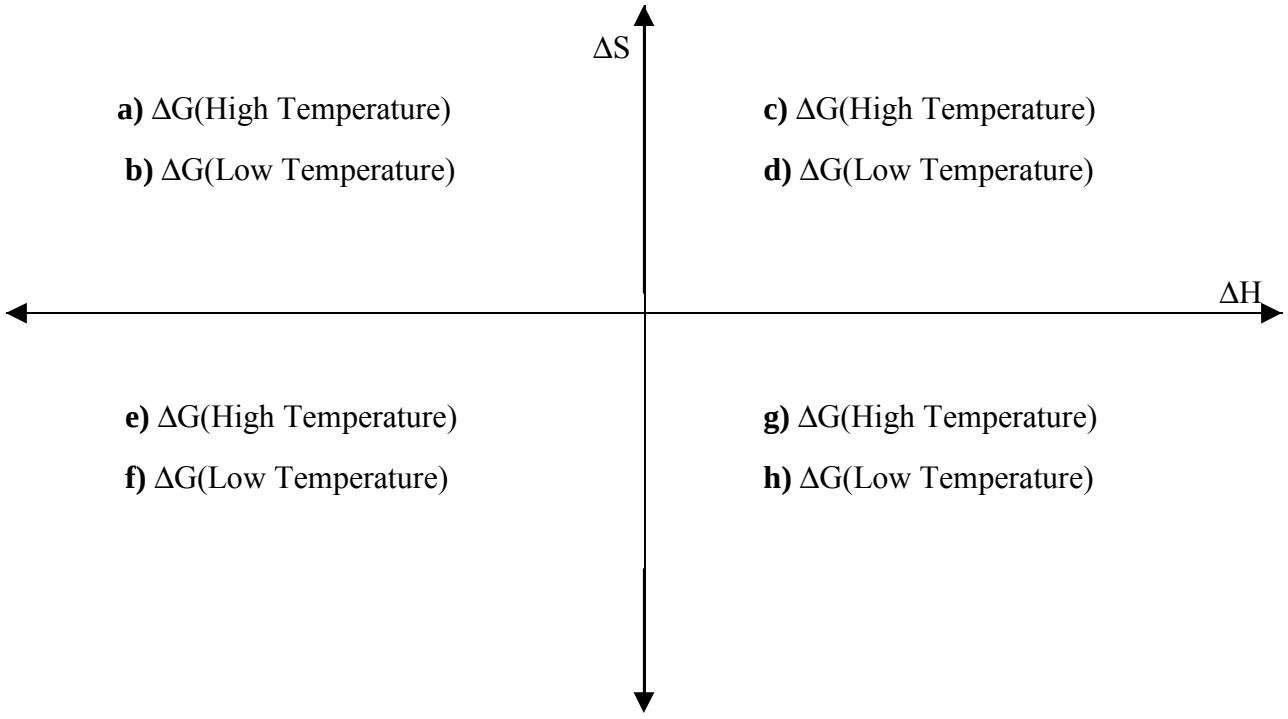
2. (10 pts) Consider the equilibrium in which a heme protein, ***P***, binds a Fe^{+2} ion from solution:

Fe^{+2} (aq) + ***P*** (aq) $\leftrightarrow$ ***P***●Fe^{+2} (aq) $\qquad\qquad$ K = 5.0 x 10^{12} at 25 ºC

(a) (5 pts) If we put 1 micromolar (ie 1.0 x 10^{-6} M) ***P***● Fe^{+2} into water, what is [***P***] at equilibrium, assuming an ideal solution?

(b) (5 pts) For the same solution as in part (a), suppose we find that, in the real solution, [***P***] = 6.0x10^{-10} M, and have measured that the activity coefficient of the protein doesn't change upon uptake of the Fe^{+2} ion. What is the activity coefficient for the Fe^{+2} ion?

3. **(10 pts)** Predict the sign of ΔG under the various conditions on the graph. Justify your answers.



a) ΔG(High Temperature)

b) ΔG(Low Temperature)

c) ΔG(High Temperature)

d) ΔG(Low Temperature)

e) ΔG(High Temperature)

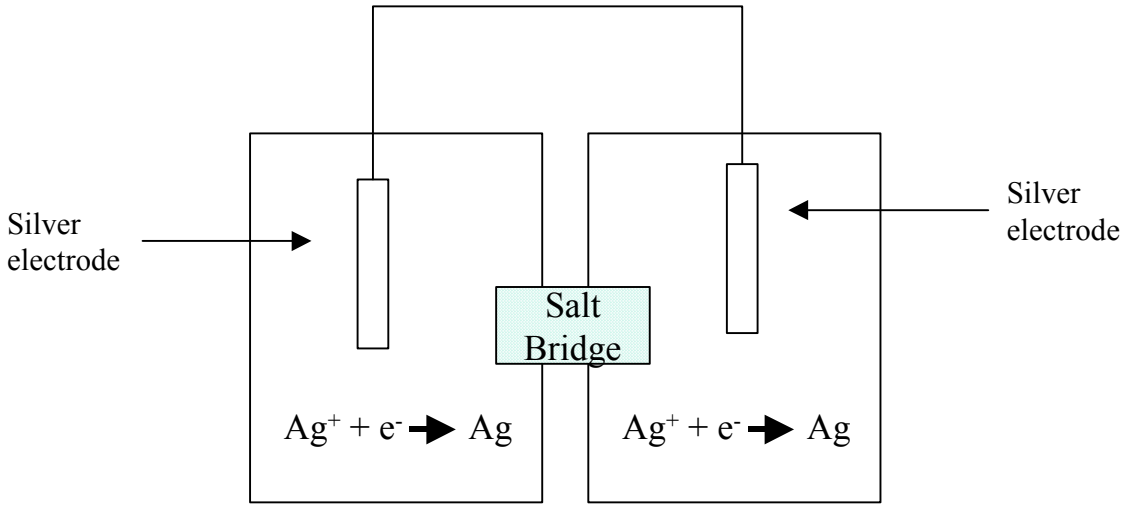
f) ΔG(Low Temperature)

g) ΔG(High Temperature)

h) ΔG(Low Temperature)

For each of a-h and the origin (ΔH=ΔS=0) indicate your choice of sign for ΔG and state why.

4. (20 pts) Consider the following galvanic cell:



Answer the following questions using the data on the page of tables. Assume we are running the reaction at 25 ºC.

(a) (5 pts) What is the equilibrium constant for the reduction of silver ion.

(b) (15 pts) If the concentration of silver ion in the left cell is 0.01M and the concentration of silver ion in the right cell is 0.1M, do electrons flow in this circuit? That is, is there a potential difference between the two half-cells? If so, what is it?

5. (5 pts) In a cell we find that a particular signal transducing kinase,K, can exist in two forms, phosphorylated (K-P) and unphosphorylated (K). In fact, we find that during a critical growth phase of our cells, the phosphorylated form is the dominant form. However, experimentally we also find that the free energy of for this reaction with inorganic phosphate is:

$$K + P_i \leftrightarrow K\text{-}P \qquad\qquad \Delta G^{\circ\prime} = 59 \text{ kJ/mol}$$

What needs to happen in order to get this kinase phosphorylated in the cell? How is this most likely accomplished?